

Navigating the Digital Wave: Challenges in Digitisation of Geraldton Fishing Boat Harbour

Paul Turney
SMEC Australia Pty Ltd, Perth, AUSTRALIA

Mick Lanham
Veris Australia Pty Ltd, Perth, AUSTRALIA

Stefanus Strydom
Mid West Ports Authority, Geraldton, AUSTRALIA



The paper showcases the challenges and achievements in digitising the maritime structures at the Mid West Ports Authority (MWPA) Geraldton Fishing Boat Harbour. Client collaboration and the expertise of specialists in maritime structures, durability, surveying, and diving resulted in detailed 3D digital CAD and structural models of 11 key jetties and wharf structures. These models provide a robust tool for MWPA, enabling proactive planning of future maintenance and improvement works, and supporting long-term success of port operational and development objectives.

The paper outlines the project's objectives of:

- determining the original and remaining structural capacity of the existing maritime assets
- identifying necessary remediation works
- providing MWPA with data needed to strategically plan investment requirements in response to growing demand.

A key achievement of this project was overcoming the challenge posed by limited available data on the original and in-situ structural geometry and capacity of the maritime structures, which were constructed using concrete, steel, and timber. The project team successfully navigated this challenge by integrating technological and digital solutions, supported by ground truthing activities.

In collaboration with specialist subcontractors Veris, SMEC conducted 3D scanning surveys, WSCAM 2022 condition assessments and both physical and non-destructive testing. These efforts validated the condition of the existing structures to inform the development of digital models.

Collaboration with MWPA was crucial in overcoming the logistical challenges of accessing all structures within the busy Geraldton Fishing Boat Harbour, enabling works to proceed with minimal disruption to harbour operations. To address access limitations, the project team employed specialist rigs to digitise piles, sub-structures and soffits on low-clearance structures, areas that traditional scanners could not access, further enhancing the completeness of the digital models.

Through tailored digital solutions, SMEC's project team simplified a complex historical challenge for MWPA. The resulting comprehensive visual 3D modelling assessment equips MWPA with a powerful decision-making tool to plan future repairs, upgrades, and facility developments in the Geraldton Fishing Boat Harbour.

Keywords: Port of Geraldton, digital engineering, maritime structures, condition and structural assessments

1.0 Reasons for the paper

This paper showcases the challenges and achievements in digitising the maritime structures at the Mid West Ports (MWPA) Geraldton Fishing Boat Harbour through client and stakeholder collaboration and the expertise of specialists in maritime structures, durability, surveying, and diving.



2.0 Background

MWPA required robust tools to support proactive planning and informed decision-making for future maintenance and improvement works at the Port of Geraldton Fishing Boat Harbour. In addition, a clear plan was needed to communicate maintenance responsibilities and the operational capacity of boat pens, wharves, and jetties to lessees, licence holders, and visitors.

Due to limited availability of original design drawings and structural calculations, both for the initial construction and subsequent upgrades, MWPA commissioned a comprehensive as-built survey and development of digital structural models of the harbour's marine assets. These were essential to achieving the project's objectives.

This paper outlines the digital techniques employed to determine the original and remaining structural capacity of maritime infrastructure, identify necessary remediation works, and provide MWPA with data needed to strategically plan investment to meet future demand.



3.0 Description of the Geraldton Fishing Boat Harbour

Located 420 km north of Perth and adjacent to the main harbour at the Port of Geraldton, the Geraldton Fishing Boat Harbour provides berthing and maintenance facilities for fishing, recreational, and tourism vessels, as well as refuelling services (see Figure 1).

The harbour comprises 11 key maritime structures: one land-backed wharf, five jetty structures, and five boat pens. These facilities support mooring, refuelling, and servicing for approximately 150 vessels. The jetty and pen structures typically consist of concrete, timber, or fibreglass grating decks and walkways; timber or steel substructures; and tubular steel or timber piles. The structures vary in age, ranging from the Long Service Jetty, constructed in 1985, to South Pens 2, completed in 2017.

The Geraldton Fishing Boat Harbour supports operations for at least 88 individual stakeholders, including leased-jetty users and pen licensees. It can accommodate vessels up to 35 metres in length, with a maximum draft of 3.5 metres.

Figure 1: Aerial view of Geraldton Fishing Boat Harbour; showing the diverse range of boat pens, jetties and wharfs offering facilities to over 150 vessels; which presents a logistical challenge for undertaking laser scanning and inspections



4.0 Methods and Techniques

To achieve the project objectives effectively, a structured three-stage approach was implemented:

- i. Collaborative project planning and risk management
- ii. On-site structural data collection and verification
- iii. Development of structural models and load capacity assessments

4.1 Collaborative project planning and risk management

Leveraging SMEC's extensive experience in delivering maritime infrastructure condition assessments in accordance with the Ports Australia Wharf Structures Condition Assessment Manual (WSCAM 2022) at the Port of Geraldton and other port facilities, the project team collaborated closely with MWPA to develop a comprehensive inspection and testing plan. This plan was informed by key perceived risks identified during the tender phase.

The primary risks to successful service delivery included:

- Limited availability of existing information, drawings, and design data to support the development of accurate structural models and as-built drawings.
- Challenges associated with conducting diving operations, laser scanning, and visual inspections within a busy fishing boat harbour comprising 147 permanent and short-term pens.
- Difficulties in capturing laser scan survey data beneath low-freeboard jetty structures.

These risks were proactively managed during the project planning phase through close collaboration with the Port, stakeholders, and site-based teams. Mitigation strategies were developed to minimise impacts on project schedule, costs, quality, safety, and harbour operations.

4.1.1 Data Availability

Due to the age of the infrastructure, existing structural data for the wharves, jetties, and boat pens was limited. However, SMEC's prior experience conducting condition assessments of assets within the Geraldton Fishing Boat Harbour provided the team with a solid foundation for understanding the general structural forms and asset hierarchy. This enabled the development of a targeted data capture plan to record key information, including physical condition, structural member dimensions, connection details, and material types, with sufficient detail to support the creation of accurate in-situ design drawings and structural models.

The data capture plan employed a multi-method approach to document structural geometry and condition, including:

- Terrestrial laser scanning and side-scan sonar: to produce a 3D digital representation of the structural geometry both above and below water.
- Diving inspections, on-water assessments, and walkover inspections: to evaluate asset condition and verify key structural member dimensions (e.g. use of a tape and micrometer) and connection details.
- Stakeholder engagement with the Port's maintenance team: to confirm material types (e.g. steel grade, concrete grade etc), pile driving records, and other undocumented asset data.
- Aerial imagery assessments and collaboration with the Port's property team: to gather design vessel information relevant to each structure.

4.1.2 Operating within a busy fishing boat harbour

A key logistical risk was the simultaneous deployment of divers, support vessels, on-water inspection crews, terrestrial laser scanners, multibeam survey vessels, and core drilling teams within the confined and active environment of the fishing boat harbour. This work required carefully coordination to minimise disruption to harbour operations, ensure safety, and maintain uninterrupted access for local businesses and boat pen licensees.

This risk was effectively mitigated through a communications and vessel relocation logistics strategy developed by the MWPA Property team. The strategy focused on minimising impact to all stakeholders and included:

- Targeted email communications to 88 stakeholders, including leased-jetty users and pen licensees, over a three-month period.
- Direct telephone contact with all 14 leased-jetty stakeholders and their sub-tenants prior to and on the day of inspections to coordinate vessel relocations.
- Telephone coordination with up to 50 individual pen licensees to facilitate timely vessel relocations in advance of inspection activities.

Additional challenges and mitigation strategies included:

- Limited pen vacancy, with occupancy at approximately 70% during inspections, reducing available relocation options.
- Scarce availability for larger vessels (18–35 m), which was addressed through coordination with other licensees and leased-jetty stakeholders to temporarily accommodate these vessels.
- Use of the Main Fisheries Wharf and fuel berth for temporary relocation of large vessels, with active monitoring to avoid disruptions to regular operations.
- Alignment of the relocation strategy with the data capture schedule to ensure areas were vacated in advance of planned laser scanning, underwater inspections, and on-water assessments.

4.1.3 Laser Scan Surveys under low Freeboard Jetties

Laser scanning requires an unobstructed line of sight to accurately capture structural geometry. For above-deck surveys, the primary challenge was the presence of vessels obstructing key areas, which was addressed through coordinated vessel relocation.

To survey the substructures of deck-on-pile jetties and wharfs, traditional approaches typically involve terrestrial laser scanning or mounting scanners directly onto multiple piles.. However, at the Geraldton Fishing Boat Harbour, several jetties present low freeboard, offering limited vertical clearance between the water level and the underside (soffit) of the structures or feature physical obstructions that prevent adequate data capture using conventional techniques (see Figure 2).

To mitigate this, a custom-designed rig was developed during the planning phase. This rig enabled surveyors to suspend laser scanners from the jetty edge, allowing accurate capture of visible substructure elements without requiring access from the water.

Figure 2: GFC Jetty; showing the low freeboard and physical obstructions; which presents challenges for access physical access and a clear line of sight for laser scanning



4.2 Onsite Structural and Condition Data Collection and Verification

Two primary techniques were employed for on-site structural and condition data collection and verification:

- Terrestrial laser scanning and side-scan sonar, which were used to capture detailed structural geometry above and below the waterline.
- Diving, on-water, and walkover condition assessments conducted in accordance with WSCAM 2022 guidelines

4.2.1 Laser scanning

Terrestrial Laser Scanning

Two laser scanning solutions were implemented to support the digitisation of structural geometry within the Geraldton Fishing Boat Harbour, each chosen to address distinct site conditions and specific data capture requirements.

A high-precision, survey-grade terrestrial laser scanner was used as the primary instrument for capturing structural geometry above the jetty edge. Capable of collecting up to one million points per second with an accuracy of ± 1.2 mm, this scanner also captures high-resolution imagery, enabling the creation of coloured point clouds. It produced the most comprehensive dataset of all above-deck surfaces across the site. The primary limitation of this instrument, however, was its size and weight (approximately 12 kg), which rendered it unsuitable for use in confined areas beneath jetties, particularly where low freeboard prevented deployment from below the deck using traditional techniques.

To address this limitation, a compact laser scanner was utilised for short-range scanning beneath the marine structures. This scanner, measuring only 16 cm in height and weighing less than 1 kg, was well-suited for capturing accurate point cloud data within restricted spaces, which was appropriate for many of the harbour's jetties and wharves, which are up to eight metres wide.

To enable safe and effective deployment of this smaller scanner, a custom-designed rig was fabricated. This rig allowed the scanner to be suspended over the jetty edge and adjusted to various heights, enabling the surveyor to navigate around obstructions and capture critical structural elements and connection details without the need for water-based access (see Figure 3). The rig could be positioned close to the deck to capture data under low freeboard structures, or the height adjusted to scan around larger beams and inaccessible substructure components.

Figure 3: Specialist scanning rig; offers mobile and lightweight scanning tool close to the jetty; enabling accurate point cloud data to be captured over short distances under for low freeboard or limited access marine structures



Bathymetric Data Capture

Bathymetric data capture was successfully undertaken using an “OTTER X” Unmanned Surface Vehicle (USV), commonly referred to as a sea drone. This compact, remotely operated vessel is equipped with a multibeam and side-scan sonar system capable of accurately mapping underwater features such as the seafloor and jetty piles.

The OTTER X’s manoeuvrability and small footprint made it particularly well-suited for operation within the confined and heavily occupied environment of the Geraldton Fishing Boat Harbour. Its ability to navigate around moored vessels allowed for effective data collection in areas where access was otherwise restricted.

The use of side-scan sonar enabled the capture of underwater features without the need to relocate private vessels within the harbour, significantly reducing operational disruption and minimising the total duration of vessel relocations when combined with other laser scanning and inspection activities.

4.2.2 WSCAM 2022 condition assessments

A comprehensive Inspection and Test Plan (ITP) was developed in accordance with WSCAM 2022, incorporating visual condition assessments, defect quantification, cathodic protection testing, and ultrasonic thickness testing. For the Main Fisheries Wharf, the scope was extended to include reinforcement cover surveys, concrete coring, potential surveys, resistivity testing, and reinforcement continuity testing.

The ITP also included the measurement of key structural member geometries, spacing, and connection details to provide ground-truth verification for the 3D laser scanning data. This dual approach was essential to mitigate the risk of incomplete data capture in a complex marine environment with low freeboard structures.

Condition assessment data was collected by multiple inspection teams (divers, on-water, and walkover inspectors) using Fulcrum, a digital field data management platform. This ensured consistency across teams using a unified asset hierarchy and standardised assessment methodology, with all data captured and stored centrally for streamlined analysis and reporting.

4.3 Structural Model Development and Load Capacity Assessment

The consolidated 3D laser scan model was exported into a 3D CAD environment, from which structural models for each jetty and boat pen were developed using SPACE GASS analysis software. These models incorporated a combination of laser scan data, ground-truth measurements, historical design drawings (where available), anecdotal information from the maintenance team, and relevant geotechnical data.

For each jetty, wharf, and boat pen structure, digital structural models were developed to represent both the ‘as-new’ condition and the current ‘in-situ’ condition. The latter accounted for observed defects including section loss and damage to structural members and connections, identified during condition inspections.

Each model was assessed under a combination of berthing, mooring, wind, wave, and thermal loads to evaluate structural performance. Member utilisation was analysed against both Ultimate Limit State (ULS) and Serviceability Limit State (SLS) load combinations, in accordance with relevant design standards.

5.0 Results

Through collaborative planning, advanced laser scanning, and comprehensive condition assessments, the project team successfully digitised 11 key jetties, boat pens, and wharf structures within the Geraldton Fishing Boat Harbour. This was achieved with minimal disruption to port operations, survey personnel, and the 88 stakeholders, including lessees and licensees.

Specialist scanning rigs were utilised to capture critical structural components and connection details that were inaccessible using conventional techniques (see Figure 4). These innovative solutions enabled safe, accurate data acquisition from the jetty edge without the need for survey personnel to operate on the water.

Figure 4: Pointcloud data obtained from specialist scanning rig; showing the rockwall, substructure and deck soffit beneath the jetty structure; enabling a full laser scan of structure, which could not be obtained using traditional techniques.

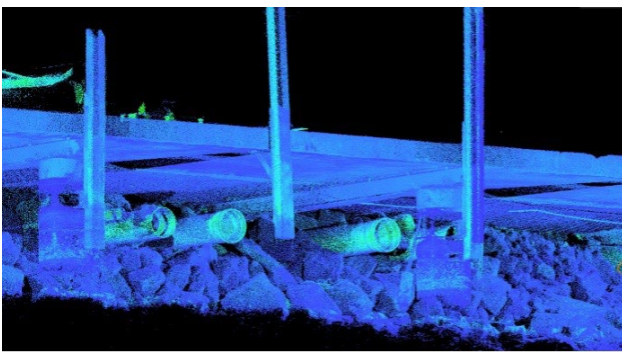
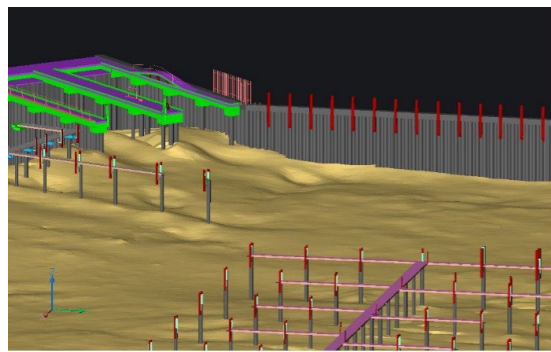


Figure 5: 3D CAD model of the laser scan pointcloud data; showing the Fishing Boat Harbour bathymetry and adjacent wharfs, jetties and pens; which enabled key input parameters to be integrated into the structural models

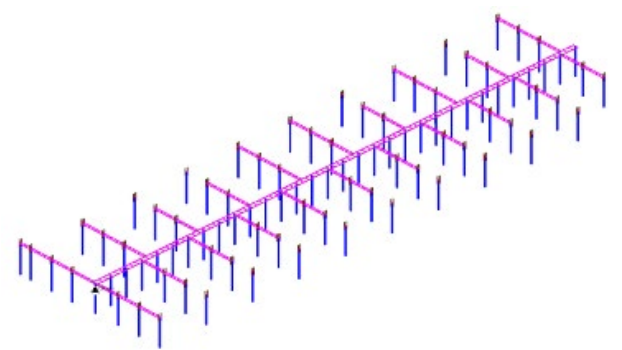


By integrating laser scan data with ground-truthed measurements and on-site observations, a high-quality 3D CAD model of the harbour's marine infrastructure and bathymetry was developed (see Figure 5).

This model served as the foundation for structural analysis.

Digital structural analysis models were created in SPACE GASS for each of the 11 structures (see Figure 6). These models identified structural elements with insufficient capacity under berthing and mooring loads, established maximum allowable vessel sizes for each facility, and defined where load restrictions are necessary.

Figure 6: SPACE GASS Model of South Pens 3; showing how the 3D CAD model was represented in a structural model; enabling a 3D comparison between the two models



The integrated findings from structural analysis and WSCAM 2022 condition assessments provided MWPA with a prioritised program of maintenance, remedial, and capital works, supporting informed investment planning and future capacity management.

6.0 Discussion

6.1 Why was this approach adopted to achieve the project objectives?

The digitisation methodology adopted for the Geraldton Fishing Boat Harbour marine infrastructure was fundamentally guided by risk mitigation principles. The most significant project risks included working in and around water, specifically:

- i. (i) the potential for personnel or equipment to fall into the water, and
- ii. (ii) the risk of collisions with moored or passing vessels.

To address these risks, the project team implemented a lateral, safety-first approach, employing innovative technologies and creative solutions to minimise the need for personnel to operate over or on the water. The approach prioritised safety while still achieving the detailed data capture required met the project's structural modelling and asset management objectives.

6.2 What were the key challenges and how were they overcome?

6.2.1 Working over water

The lack of structural data for the marine infrastructure required data capture and modelling of features only visible from the water level. Traditionally, this type of survey would require the capture team to take measurements from a vessel, exposing them to the risk of falling overboard. To mitigate this risk, an Unmanned Surface Vehicle (USV) and multiple laser scanners were deployed, allowing operations from land without the need to be on the water.

Additionally, many of the jetties and pens around the Geraldton Fishing Boat Harbour had low freeboard and therefore there was insufficient space for a vessel to go underneath to capture data. To overcome this limitation, scanners mounted on specialist rigs were used, enabling for data capture in these hard-to-reach areas.

6.2.2 Capture of Bathymetric Data

Conventional hydrographic vessels are generally too large for these types of projects and lack the versatility to navigate in small spaces. To mitigate this issue, a specialist USV operator to drive the remote vessel throughout the site and capture all underwater piles and sea floor levels. The USV was fitted with a multibeam side scanner that could capture data in areas where low headroom and vessel mooring restricted direct access.

Figure 7: Unmanned Surface Vehicle; with lower freeboard and size compared to conventional survey vessels; offering greater versatility for surveying in tight locations



6.2.3 Combining datasets

The use of multiple technologies for data capture introduced the challenge of maintaining alignment and accuracy across all datasets. To address this, the project team adopted a strategy of capturing overlapping data points on redundant structural features using different technologies. These shared reference points enabled validation and alignment of datasets along both horizontal and vertical axes, ensuring the consistent and accurate integration of all captured information.

6.3 Development Opportunities

With sufficient time, budget and alignment to the client's asset management strategy and supporting systems for asset tracking, lifecycle management and maintenance scheduling, there are many opportunities to expand the use of digital technology in asset condition and digitisation.






These may include comparative 3D photogrammetric survey models and remote sensing technologies, with outputs integrated into BIM models to serve as a 'single source of truth' for asset data. Such integration provides a comprehensive and centralised view of the infrastructure assets across their lifecycle. This allows client asset managers to make more informed decisions, optimise operations, reduce costs and improve communication with stakeholders, maintenance teams, engineers and management personnel. However, digital data capture and management systems offer substantial benefits in terms of cost, time, quality and safety, it remains essential that they are complemented by on-site physical inspections and testing by professionals to ground truth the digitally captured data.

Conclusion

Collaboration with MWPA was crucial in overcoming the logistical challenges of accessing all structures within the busy Geraldton Fishing Boat Harbour, ensuring minimal disruption to harbour operations. To further enhance the completeness of the structural models, the team utilised specialist scanning rigs to digitise piles, substructures and soffits on low-clearance structures that were inaccessible using traditional scanners, further enhancing the completeness of the models.

Through tailored digital problem-solving, SMEC’s team simplified a complex historical challenge for MWPA. The development of a comprehensive visual 3D modelling assessment equips MWPA with the tools to make informed decisions regarding future repairs, upgrades, and facility developments within the Geraldton Fishing Boat Harbour.

Sustainable Development Goals

SDG	Description	Relevance to Paper
 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	Industry, innovation and infrastructure	Use of smart technologies in infrastructure delivery.
 11 SUSTAINABLE CITIES AND COMMUNITIES	Sustainable Cities and Communities	Maintaining and enhancing key infrastructure that supports local industry and community use, while minimising disruption during works.
 13 CLIMATE ACTION	Climate Action	Asset digitisation and lifecycle modelling enable smarter, more efficient maintenance and upgrade decisions, helping to reduce resource waste and extend asset lifespans.
 14 LIFE BELOW WATER	Life Below water	Minimising disruption to the marine environment during inspection and using non-invasive technologies aligns with the goal to protect aquatic ecosystems.
 17 PARTNERSHIPS FOR THE GOALS	Partnerships for the Goals	Project partnership focused on collaboration and cooperation to collectively achieve sustainable development.

Acknowledgements

The authors would like to thank Mid West Ports Authority for its proactive and considerable support of the project through stakeholder co-ordination and for investigating anecdotal evidence on the design, construction, and maintenance of the Geraldton Fishing Boat Harbour structures.



Authors

Paul Turney

SMEC Australia Pty Ltd, Perth, AUSTRALIA

Stefanus Strydom

Mid West Ports Authority, Geraldton, AUSTRALIA

Mick Lanham

Veris Australia Pty Ltd, Perth, AUSTRALIA

SMEC simplifies the complex. We unlock the potential of our people to look at infrastructure differently, creating better outcomes for the future.

www.smec.com